TECHNICAL BULLETIN No. 1

WEST AFRICAN CACAO RESEARCH INSTITUTE

A SUMMARY

OF THE

RESULTS OF CAPSID RESEARCH

IN THE GOLD COAST

D. J. TAYLOR

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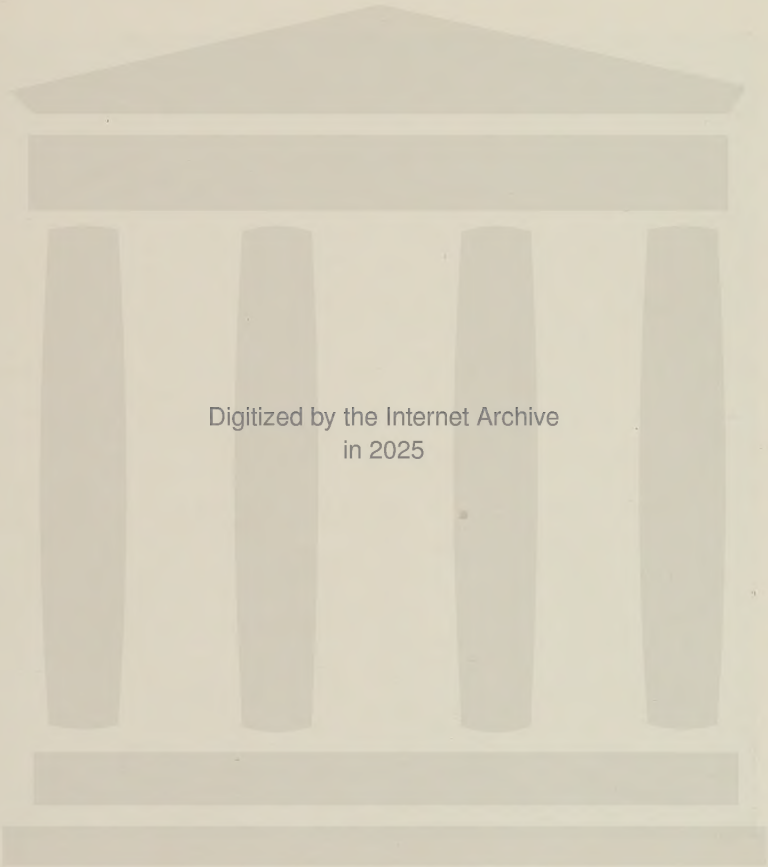

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Chronic damage in a 'capsid pocket'.

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D. J. TAYLOR

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WEST AFRICAN CACAO RESEARCH INSTITUTE

The West African Cacao Research Institute was founded in 1944 and is incorporated by the West African Cocoa Research Institute Ordinance, 1947 in the Gold Coast. It has legal status in Nigeria also by virtue of the West African Cocoa Research Institute (Nigerian Status) Ordinance, 1950.

The Institute is financed partly from funds set aside by the former West African Cocoa Control Scheme and partly from grants provided by the Gold Coast and Nigerian Cocoa Marketing Boards.

Its research programme is designed to study all the fundamental problems which affect the cocoa crop in West Africa and, in particular, to work out ways and means of applying scientific principles and the results of scientific research to the day-to-day problems of the cocoa grower.

The main research station is situated at Tafo, Gold Coast, some seventy miles north of Accra and a sub-station has been opened at Ibadan, Nigeria. The Institute is engaged solely on research work and has no executive authority or direct responsibility for extension work in the countries which it serves. Visits to the Institute from farmers are welcomed and are, indeed, organised by the Departments of Agriculture, but the results of research at the Institute are made available to the cocoa growers through the officers of the Departments of Agriculture.

The Senior Research Staff consists mainly of officers of the Colonial Agricultural and Colonial Research Services. Two scholarships are offered to citizens of the Gold Coast and Nigeria to provide post-graduate training of a standard to qualify them for the Institute's service. Particulars of these awards may be obtained from the Director.

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FOREWORD

This paper by Mr. D. J. Taylor is the first of a new series of publications issued by the Institute, to be known as Technical Bulletins. Each is to be a concise exposition of the work on a particular problem, either, as in the present case, a summary and discussion of progress in a continuing investigation, or an account of the results of a completed investigation for general information.

The bulletins are designed primarily for the information and guidance of those responsible for agricultural education and extension work in West Africa, but it is hoped that they will also be of considerable interest to all who are connected, directly or indirectly, with West African agriculture. The rapid spread of education in the area also gives rise to the hope that the bulletins will appeal to an ever-increasing public in West Africa itself, especially to those engaged in cocoa production.

Extracts from the bulletins may be reprinted without restriction, provided that the source of the information is fully acknowledged.

ALAN PICKLES,
Acting Director.

A SUMMARY OF THE RESULTS OF CAPSID RESEARCH IN THE GOLD COAST.

D. J. Taylor, *Entomologist*

West African Cacao Research Institute

I. Introduction.

The feeding activities of certain insects of the family Miridae (Capsidae) have been recognised as the cause of serious injury to cacao trees in the Gold Coast for nearly fifty years. As will appear, the effects of attack by these insects vary greatly according to the circumstances, and range from a slight temporary set-back to the death of trees affected. An accurate estimate of the economic losses caused by these pests is hardly possible but it has been unofficially estimated that the losses in the Gold Coast amount to between 60,000 tons to 80,000 tons dry cacao annually (Hale 1953). At the present world prices this represents a financial loss of somewhere in the region of £25,000,000. It has been stated (Johns and Gibberd 1951) that, in Nigeria, the losses from the combined primary and secondary effects of capsid attack are far in excess of those caused by any other pest or disease and, for comparison, it may be added that, in a bad year, up to 30,000 tons are lost through black pod disease in that country. During the discussions at the Cocoa Conference held in London in 1953 opinions were expressed to the effect that capsid attack was the most important factor limiting cacao production at the present time.

While much study has been devoted to these insects, to the damage which they cause and to the possible methods of control, information concerning them is scattered through numerous scientific papers and articles and in the Annual Reports of the Institute. The present time appears opportune for a concise but comprehensive review of all this information.

During the period under review the nomenclature of the insects has altered. The names used throughout this summary are those current at the time of writing.

II. Species involved.

Although Capsid damage had been reported earlier in the Cameroons, it was in 1907–8 that such damage was first noticed on cacao in the Gold Coast Colony and Ashanti. Dudgeon (1910, a & b) referred to the ravages of the three species *Distantiella theobroma* (Dist.) (Fig. 1a), *Sahlbergella singularis* Hagl., (Fig. 1b), and *Helopeltis bergrothi* Reut. A fourth species, *Bryocoropsis laticollis* Schum, was discovered attacking cacao by Cotterell in 1939 (Cotterell 1943). *H. bergrothi* and *B. laticollis*, however, feed and breed almost exclusively on cacao pods when attacking this host. While they cause some scarring of the pods, their economic importance is slight at present and most of the studies recorded here have

been restricted to the major economic species. *S. singularis* and *D. theobroma*, which attack the vegetative parts of the tree in addition to the pods.

S. singularis is recorded from all the cacao-growing areas of West and West Central Africa ; *D. theobroma* occurs only west of the Cameroons in this region (Anon, 1952 a & b), so far as is known. In the Gold Coast these species are coextensive in range.

Cotterell (1926) and Box (1944) recorded that, while *S. singularis* was primarily a pest of mature cacao, *D. theobroma* confined its attention to young seedlings. More recently, however, Squire (1947) and Williams (1953 b) have found that both species attack cacao of all ages ; it seems probable that a change in feeding habits has occurred during the past decade.

III. Capsid Damage and the Role of *Calonectria Rigidiuscula*.

Both *S. singularis* and *D. theobroma* may be considered typical plant-feeding Heteroptera. The primary damage, which is not restricted to the point of insertion of the stylets, has been demonstrated by Goodchild (1952) to be due to the histolytic effect of esterases in the saliva injected into the wound. No organic pathogens have been found in the saliva (Squire 1947). This primary damage is not nearly so important as the damage caused by the subsequent invasion of the wounds by the fungus *Calonectria rigidiuscula* (Berk. and Br.) Sacc., (Anon 1946). This fungus has been proved by Crowdy (1947) to be associated with much of the die-back previously attributed solely to capsids.

The stylets, which were found to be 1·8–2·2 m.m. long in the adult capsids, enter at right angles to the axis of the stem and then may turn up sharply (Anon 1946). The course of development of the lesions has been described in the W.A.C.R.I. Annual Report 1945–46, and by Crowdy (1947). The first symptom to appear is a water-soaked area, which may be up to 3–4 m.m. in diameter, around the site of the original puncture. This becomes depressed owing to the collapse of the underlying tissue, and turns black within a few hours. A black elliptical lesion develops from this (Fig. 2).

On a greenshoot, the effect of the saliva and the mechanical damage may be sufficient to cause its death.

On hardened stems the mechanical effect is less important, and the damage, due to the phytotoxic effect of acidity produced by the action on esterases in the saliva, occurs mainly in the medullary rays of the cortex and only slightly in the medullary rays of the xylem. Medullary ray cambium is also destroyed, but little damage occurs to the phloem or phloem cambium, i.e., damage is confined to the medullary rays in the peripheral tissues. Provided infection by *C. rigidiuscula* does not take place, the lesion heals about three days after puncturing. The primary cambium reconstitutes *in situ* and separates medullary ray tissue of xylem from that of phloem. The dead cortical tissues fall away, leaving the

phloem fibres adhering to the surface of the lesion in a characteristic network pattern. No cankering or bark roughening takes place.

With lesions which become infected with *C. rigidiuscula* the initial effects are similar. However, the subsequent damage is not confined to the medullary rays in the peripheral tissues, but spreads to the phloem and xylem and, after about two weeks, a considerable area is involved. The fungus mycelium, which is not confined to the unlignified regions, is in the main intercellular, although haustoria are occasionally found within the phloem. The extensive damage precludes the reconstitution of the cambium *in situ* and the lesion heals by the growth of callus tissues from the edges (Fig. 3). The infected lesion is characterised by a deep seated canker extending into the xylem, and by the roughened bark which appears as the lesion finally becomes occluded (Fig. 4). In areas where the environmental conditions are unsuitable for cacao cultivation, or during periods when the trees are weakened through drought, the fungus spreads back from the site of invasion, with the subsequent death of the branch.

On pods the feeding site is marked by a plug of blackened tissue, but this does not penetrate into the interior of the pod.

In the field three fairly distinct forms of damage associated with capsid attack on mature cacao may be recognised. The first, which is seasonal in occurrence, has comparatively little permanent effect on the well-being of the trees. It is due to the capsids feeding on the fan shoots after the main crop of pods has been removed. The shoots are rapidly killed and the leaves turn brown and remain hanging on the tree for some time. This is termed " blast ". More important are the areas of unthrifty and heavily cankered trees resulting from persistent attack (Frontis piece). The crown of such trees is usually much reduced as a result of infection by *C. rigidiuscula*, and is only thinly clothed with leaves. Cacao in this chronic condition is described as " Stag-headed." The third type of injury is acute damage, usually confined to small groups of less than 100 trees ; the canopy branches are completely lost and prodigious chupon growth takes place. The chupons in turn are persistently attacked by capsids. Such areas are termed " Capsid pockets " and are permanent foci of populations (Anon 1949). These pockets develop where the cacao canopy has been broken, (Williams 1953 a), a condition resulting most frequently from the die-back associated with adverse water relations and the damage caused by falling shade trees.

IV. Factors Associated with Damage.

1. *Overhead shade.*

The influence of overhead shade on capsid damage remains somewhat obscure and, as the conclusions of various workers are not entirely in accord, it is evident that this aspect of the capsid problem requires further study. Since both excessive shade and depleted shade render the cacao susceptible to attack or reduce its power of regeneration from injury, the problem is a complex one.

It does appear, however, that those shade conditions which are most suitable for the healthy growth of cacao are also those in which capsid injury is least likely to be serious.

From observations on small plots of cacao in the Gold Coast, Posnette (1943) concluded that " whilst total damage due to *Sahlbergella* is higher on unshaded plots, severe damage is greater on shaded plots." In the absence of further details, this statement may be interpreted to indicate that damage occurred extensively throughout the unshaded plots but that, under-shade, damage was restricted to particular trees or parts of trees but was intense where it did occur.

Squire (1947) has recorded that " pockets " are associated with cultivation under-shade ; when cacao is grown without shade, capsid damage occurs in a more diffuse form, as in Nigeria and the Ivory Coast, and pockets are less frequently observed.

Williams (1953 a) surveyed and analysed the inter-relationships of shade and capsid damage in over a thousand sites in the cacao belt of the Gold Coast and showed that conditions of shade influenced both the incidence of attack and the severity of damage. He confirmed the fact, already recognised, that attacks are most likely to occur where the cacao canopy is broken or is discontinuous : where it has been damaged by mechanical causes, such as a falling branch from a shade tree, or where the canopy is depleted owing to the death of trees, or to depleted growth on account of disease, adverse water relations or faulty shade conditions.

Where shade was dense or very dense and only just cleared the top of the cacao, etiolation of young cacao occurred ; this resulted in delay in the formation of a continuous cacao canopy and, even after many years, the canopy remained thin and generally discontinuous and such areas were consequently highly subject to attack by capsids. On the other hand, areas which were unshaded or only sparsely shaded were also highly subject to attack, since the formation of a continuous canopy was retarded by exposure. Increasing intensities of tall shade, however, were found to favour the early development of a continuous canopy, since the cacao was protected against exposure but the shade density was not so great as to cause etiolation and such areas were less susceptible to attack by capsids.

Williams also found that, when capsid attack does occur, its severity is greatest under dense and very dense shade. He found severe damage in 67 per cent. of his stations where the canopy was broken under dense shade and in only 58 per cent. of the stations where it was broken under sparse shade. While the difference is not great, it was statistically significant and is some confirmation of the conclusions of Posnette mentioned earlier.

The relation between a broken cacao canopy and capsid attack is undoubted, but the reasons for such a relation are not entirely clear ; the relation is not absolute, for capsid " blast " may occur

Fig. 1a. Adult female, *Distantiella theobroma* (Dist).

Fig. 1b. Adult female, *Sahlbergella singularis* Hagl.

Fig. 2. Primary lesions developing around capsid feeding-punctures.

Fig. 3. Infected lesions becoming occluded by the growth of callus tissue from the edges.

Fig. 4. Roughened bark which appears after the infected lesions have become occluded.

in cacao with a continuous canopy. The " stag headed " form of damage is most likely to occur in unshaded or under-shaded cacao, while " pockets " are more particularly associated with cacao growing under very dense shade. " Pockets " may ultimately arise, however, wherever capsid attack is persistent owing to continuous invasion of the healthy tissues of the trees by *Calonectria* fungus.

2. *Soils.*

In the Eastern Province of the Gold Coast, counts at Akwadum (Anon 1947) indicated a high incidence of capsids on plots on all the three main soil series. Capsid damage has been recorded from sites representing all the soils on which cacao is grown in the Gold Coast. It is probable that the water relationships and nutrient status of the soil may affect the spread of *C. rigidiuscula* in the tree (Anon 1947) and obviously adverse edaphic factors would delay the recovery from damage associated with capsid attack. However, at present there is no evidence to suggest a correlation between capsid attack and soil type.

V. Life History and Bionomics.

Studies of the life history and mode of life have been made by Cotterell (1926) and, more recently, by workers of the West African Cacao Research Institute (Anon 1946, 1947).

The eggs are laid in the cortex of pods and below the bark of shoots. The eggs are inserted at an angle and lie buried beneath the epidermis, with only a pair of fine apical processes, bearing numerous micropyles, projecting from the surface. The rate of oviposition is higher for *D. theobroma* than *S. singularis*. The maximum recorded number of eggs laid by one female, is 47 for *S. singularis*, and 192 for *D. theobroma*. The average incubation period for *S. singularis* is 17 days, and for *D. theobroma*, 15 days.

There are five nymphal instars, each with a duration of 4–5 days. Feeding takes place during all instars.

The average period from egg to adult for *S. singularis* is 41 days, and for *D. theobroma* 39 days. There is a pre-maturity period for both species of about a week, and the longevity of the adults varies from 25–30 days. The proportion of females is greater than that of males.

Williams (1953 a) has shown that egg-laying takes place mainly on chupons and pods. Fan tissue is rarely used as a breeding site.

VI. Alternative Hosts.

Other hosts have been widely searched for, and extensively studied, (Box 1944 ; Anon 1947, 1948, 1949, 1950 ; Squire 1947).

D. theobroma has been observed feeding and breeding on *Ceiba pentandra* Gaertn. in the cacao growing areas of the Gold Coast, although a search on this and other trees in the Northern Territories has failed to reveal its presence. In Nigeria, near Ibadan, *D. theobroma* has not been found on *C. pentandra*, although surrounding

cacao was infested. *D. theobroma* has however been recorded attacking citrus near Ibadan (Golding 1941).

S. singularis has been recorded on *Cola millenii* K. Schum., *Ceiba pentandra* Gaertn., *Sterculia foetida* Linn and *Nesogordonia papaverifera* (A. Chev.) R. Capuron in the Gold Coast. Except for *Nesogordonia papaverifera*, it has been possible to breed *S. singularis*, under insectary conditions, on all these plants successfully. It has also completed the life-cycle in the insectary on *Cola nitida* (Vent.) Schott and Endl., *Cola gigantea* A. Chev., *var nov*, *Sterculia rhinopetala* K. Schum., and a species of *Bombax*. Recently an officer of the Department of Agriculture reported *S. singularis* feeding on the fruits of a tree of the *Cola maclaudii/lateritia* complex, in Ashanti.

VII. Capsid Populations.

Owing to the nature of the canopy of cacao, and the difficulty of searching in it without causing damage, an ideal sampling technique has not yet been elaborated.

Nicol (1945) has described routine collecting and recording of capsids daily by a group of collectors, walking through different localities on successive days near Tafo. This method was practised from 1944 to 1948 and, although it has obvious dis-advantages, it has indicated the gross fluctuations throughout the year with some reliability and has shown the most striking differences between successive years. Williams (1953 a) counted, without collecting, capsids in plots of individually numbered trees. With the use of ladders all the trees were totally examined twice monthly and the details of numbers of eggs, nymphs and adults and their positions on the tree were recorded. Williams (1953 a) also tried to obtain an index of the population by estimating damage, but he pointed out that this only gave a rough estimate of the population.

The figures obtained from the routine collections agreed well with those obtained from the intensively searched plots. At Tafo the population is low from March to July. It then increases gradually, the peak for *S. singularis* occurring in December–January, and that for *D. theobroma* in January–February ; this is followed by a sharp decline. The general shape of the curve is the same each year though the actual level varies, (Anon 1946 ; 1947 ; 1948 ; 1949 ; 1950.). Routine counts at Owena in Nigeria have indicated similar population trends, though the peak occurs in August and September (Anon 1948).

VIII. Ecological Factors Affecting the Population.

The cause or causes of this seasonal variation have not been satisfactorily explained. Squire (1947) suggested that the direct influence of seasons on the capsid population is slight compared with that factor introduced by fruiting during the crop months. But it has been shown (Anon 1949) that the build up is independent of the presence of pods, and Williams (1953 b) is of the opinion that

the coincidence of the increase of pods and of capsid populations is not one of cause and effect, but of correlation with the same under-lying factors.

Apart from consideration of the association between shade and capsid damage, there has been little study of the environment of capsids. The most obvious factors which influence the abundance of insects are those connected with climate. The intra-specific, and inter-specific relationships must also be important, but are probably subordinate to the influence of climate. The experimental work on these factors which has been carried out is fragmentary and not conclusive.

1. *Moisture and Temperature.*

Cotterell (1943) stated that a relative humidity of "about 60%" is critical. He also found that both *S. singularis* and *D. theobroma* could withstand a temperature of 90°F for 48 hours. However, he did not mention the other conditions obtaining at which these values were determined, and it would appear that the combined effects of moisture and temperature were not considered.

Experiments were conducted (Anon 1951) to observe the reaction of capsids to different temperatures. A temperature gradient apparatus was used in which the gradient was linear, ranging from 13°C to 45°C. It was found that the frequency distribution of the capsids with regard to temperature was bimodal. The lower mode occurred at 17°C–19°C for females and at 23°–25°C for males of both species. The second mode was at 32°–34°C, except in the case of females of *D. theobroma* for which the second mode occurred at 35–37°C. It was stated that below 16°C the insects were trapped in condensation water, and above 43°C they rapidly became moribund.

2. *Light.*

Experiments were conducted (Anon 1951) to see whether sunlight had any effect on the development of capsids. Gravid females were caged on seedlings, some of which were exposed to sunlight and some kept in the shade. There was a general indication that females of both species laid more eggs in the shade, but true comparisons were not obtained because the high temperatures in the sunlit cages caused considerable mortality amongst the gravid females.

3. *Biotic Factors.*

At periods of high population the density-dependant factors operate with the consequent intra-specific competition for food. Williams (1953 a) has pointed out that, because of the destructiveness of their feeding and their sedentary habits, a considerable proportion of the nymphs die of starvation. Another effect which Williams (1953 b) has reported is the lengthening of the period of development in November, December and January in the case of *S. singularis*, and in December, January and February with *D. theobroma*, that is, during their peak population months.

The inter-specific relationships involve not only the competition between the two species of economic capsids, but also the limiting effects of predators and parasites. Williams (1953 b) pointed out that there is competition for breeding sites on chupons between the two species but that their co-existence is possible because of their slightly differing habits. *S. singularis* is more diffusely distributed than *D. theobroma* over the tree, but the population of the latter species can build up quickly because of its greater rate of egg production.

There has been no quantitive estimate of the effect of predators. Numerous mantids, reduvids, spiders and lizards have been recorded preying on capsids, though none confines its attention solely to capsids (Cotterell, 1943 ; Anon. 1947). The discovery in badly attacked areas, that trees free from capsid damage were infested by *Oecophylla longinoda* (latr.) and *Macromischoides aculeatus* Mayr., suggested that these ants were reducing the caspid populations or preventing their establishment (Cotterell 1943 ; Anon 1946). However, field trials have shown that the association is due to the colonisation of healthy trees remaining after the surrounding trees had been so badly damaged by capsids that they were unsuitable for the ants (Anon., 1949 ; Anon. 1950).

Hymenopterous endoparasites have been obtained from both capsid species. *S. singularis* is parasitised by *Euphorus sahlbergellae* Wilk., which is in turn attacked by the hyper parasite *Mesochorus melanothorax* Wilk. It has been reported that both at Tafo (Anon 1946) and at Owena (Anon 1947) the percentage parasitism of *S. singularis* by *E. sahlbergellae* attains a maximum of about 30%, two months after the host population peak. The only Hymenopterous parasite which has been bred from *D. theobroma* is *Encyrtus cotterelli* Waterst. (Waterston 1922). Intensive searches have not indicated the presence of egg parasites, (Anon 1947 ; 1949).

IX. Control.

1. *Cultural.*

Work at W.A.C.R.I. (Anon 1947 ; 1949 ; 1951 ; 1953) has shown that it is possible to regenerate mature damaged cacao in capsid pockets by coppicing the trees at 4″–6″ above the ground, and subsequently treating the chupons with DDT emulsion. Two or three chupons were allowed to grow from each stump but, as the canopy formed, they were reduced, leaving a single chupon to form the tree. In two areas treated in this manner in 1946 and 1950, 85–90% of the coppiced stumps produced chupons, and some trees were in bearing within two and a half years. It has been found that, whilst the application of insecticides to damaged mature trees will arrest further attack, it does not result in the formation of a well-shaped tree and canopy.

Attempts have been made to obtain a cacao resistant to capsid attack, and several promising selections were made (Posnette

1943 ; Anon 1946 ; Anon 1947). However, subsequent field trials showed no significant differences between the susceptibility of these selections and ordinary West African Amelonado cacao.

2. *Biological.*

The possibility of introducing a parasite to control capsids biologically has been considered, and searches have been made in Sierra Leone and the Belgian Congo. The results were not encouraging (Anon 1947) and it seems unlikely that further work in this direction will prove fruitful.

3. *Chemical.*

One of the earliest measures adopted for the control of capsids was the use of a spray of kerosene emulsion (Dudgeon 1910). This, however, only produced a low mortality of the insects and Cotterell (1926) suggested the use of nicotine sulphate. He pointed out that a nicotine spray would be more efficient, but he recommended dusts for general use, since larger trees could be treated and the expensive transport of water could be avoided.

Cotterell (1943) referred to spraying trials using several concentrations of nicotine sulphate, lime sulphur, and Tropical Mortegg. Even in low concentrations the last two preparations caused leaf scorch, whereas a spray made up of 40% Nicotine Sulphate at a concentration of 1 : 1000 was said to give 100% mortality. Power sprayers working at high pressure were used to give good coverage.

The discovery of the insecticidal properties of the halogenated hydrocarbons offered new possibilities for capsid control. It was shown that a 1% solution of DDT in a vegetable oil and water emulsion killed both *Sahlbergella* and *Distantiella* and had a considerable residual toxicity (Anon 1948). Part of an area which was badly damaged by the fall of a silk cotton tree in February 1949 was prevented from deteriorating into a capsid pocket by spraying with 1% DDT wettable powder in May and September 1949, and January, 1950, (Anon 1951). The untreated section developed into a pocket.

The suitability of various spraying machines has been tested (Anon 1951), but the ideal equipment has not been found.

As with all spraying methods the wastage is high and the transport of water, which is often difficult to obtain, is one of the major costs in spraying. Experiments were started (Anon 1946) to devise more economical methods. Application of a DDT preparation with a paint brush to the leaf axils and the junctions of young stems and branches—the resting places of the nymphs and adults during the day, was found to be effective (Anon. 1948) and a small-scale field trial was laid down in 1946. The trees in six plots were treated with 2·5% DDT-xylene emulsion, and the trees in another six plots were left untreated. After 20 weeks 84% of the capsids found were on the untreated plots. Further field trials were carried out (Anon 1949 ; 1950), including a large-scale field trial on a 26-acre area of seedlings. The seedlings in half the area were painted

in 1947 with 2·5% DDT emulsion while the others were untreated. The treatment was continued and a count, made eighteen months after the initial treatment, showed that 26·7% of the seedlings in the untreated area were damaged compared with only 0·01% of the treated seedlings. In order to control capsids on seedlings, it has been recommended that three applications of this 2·5% DDT emulsion are made during the year, that is, during February, June–July and November.

A method has been sought to apply this principle to larger trees (Anon 1953 a). Trials were carried out using a modified knapsack sprayer, carrying a long light-weight lance with a trigger valve. The nozzles used gave a narrow-angle cone of relatively coarse droplets. With this equipment the application of the insecticide in quick short bursts is possible, and the insecticide can be applied in small quantities to those parts of the tree where it is required. Large scale trials are in progress using this "spray-painting" method (Anon 1953 b).

Tests carried out (Anon 1951 ; 1953 a) in both the wet and dry seasons have shown that the use of insecticidal smokes is not practicable, as the smoke immediately penetrates through the canopy and rolls over its surface without being deposited on the resting and feeding sites of the insects.

It is considered at present that the best method of controlling capsids in mature cacao is by the use of DDT dusts (Anon 1953 b), and recently an efficient light-weight dusting machine has been developed, which can be easily used in cacao farms. Trials have indicated (Anon 1953 c) that pollinating insects are not adversely affected by insecticidal dusts, even when these are applied at three-weekly intervals.

Conclusions.

In the light of present information, insecticidal methods seem to offer the best prospects for the control of Capsids in West Africa. The protection of young cacao, by the simple expedient of painting strategic parts of the tree with a persistent insecticide, may be said to be virtually accomplished, though it may be possible to time the applications more precisely with advantage. With older trees, dusting and spray-painting give promise of success. The problem still remains, however, of convincing the West African farmer of the value of these methods and of persuading him to adopt them.

Much more research is needed on other aspects of the capsid problem and the relation of overhead shade and cacao canopy to the occurrence and severity of capsid attack, in particular, requires further investigation.

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